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In re Patent Application of:	)
Daisuke KUMAKI et al.	) Examiner: Meiya Li
Serial No. 10/580,535	) Group Art Unit: 2811
Filed: May 25, 2006	)
For:	)
LIGHT-EMITTING ELEMENT	)
	)

VERIFICATION OF TRANSLATION

Commissioner for Patents
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Dear Sir:

I, Hiroyuki SONE, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached English translation of the Japanese Patent Application No. 2003-432306 filed on December 26, 2003; and

that to the best of my knowledge and belief the following is a true and correct English translation of the Japanese Patent Application No. 2003-432306 filed on December 26, 2003.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: this 30 day of September 2010

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[Attention]	Commissioner, Patent Office
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[Attachment]	Scope of Claims 1
[Attachment]	Specification 1
[Attachment]	Drawing 1
[Attachment]	Abstract 1

[Name of Document] Scope of Claims

[Claim 1]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing an n-type semiconductor, and a third layer containing a p-type semiconductor between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 2]

A light-emitting element according to claim 1, characterized in that the n-type semiconductor is metal oxide.

[Claim 3]

A light-emitting element according to claim 1, characterized in that the n-type semiconductor is a compound or two or more compounds selected from a group consisting of zinc oxide, tin oxide, and titanium oxide.

[Claim 4]

A light-emitting element according to claim 1, characterized in that the p-type semiconductor is metal oxide.

[Claim 5]

A light-emitting element according to claim 1, characterized in that the p-type semiconductor is a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide.

[Claim 6]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing an organic compound and a material showing an electron donor property for the organic compound, and a third layer containing a p-type semiconductor between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 7]

A light-emitting element according to claim 6, characterized in that the p-type semiconductor is metal oxide.

[Claim 8]

A light-emitting element according to claim 6, characterized in that the p-type semiconductor is a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide.

[Claim 9]

A light-emitting element according to claim 6, characterized in that the organic compound is an organic compound showing an electron transporting property.

[Claim 10]

A light-emitting element according to claim 6, characterized in that the organic compound is a metal complex having a ligand containing a π-conjugated skeleton.

[Claim 11]

A light-emitting element according to claim 6, characterized in that the material showing an electron donor property is an alkali metal, an alkaline earth metal, or a rare

earth metal.

[Claim 12]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing an n-type semiconductor, and a third layer containing an organic compound and a material showing an electron accepter property for the organic compound between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 13]

A light-emitting element according to claim 12, characterized in that the n-type semiconductor is metal oxide.

[Claim 14]

A light-emitting element according to claim 12, characterized in that the n-type semiconductor is a compound or two or more compounds selected from a group consisting of zinc oxide, tin oxide, and titanium oxide.

[Claim 15]

A light-emitting element according to claim 12, characterized in that the organic compound is an organic compound of a hole transporting property.

[Claim 16]

A light-emitting element according to claim 12, characterized in that the organic compound is an organic compound having an aromatic amine skeleton.

[Claim 17]

A light-emitting element according to claim 12, characterized in that the

material showing an electron accepter property is metal oxide.

[Claim 18]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing a first organic compound and a material showing an electron donor property for the first organic compound, and a third layer containing a second organic compound and a material showing an electron acceptor property for the second organic compound between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 19]

A light-emitting element according to claim 18, characterized in that the first organic compound is an organic compound showing an electron transporting property.

[Claim 20]

A light-emitting element according to claim 18, characterized in that the first organic compound is a metal complex having a ligand containing a π-conjugated skeleton.

[Claim 21]

A light-emitting element according to claim 18, characterized in that the material showing an electron donor property is an alkali metal, an alkaline earth metal, or a rare earth metal.

[Claim 22]

A light-emitting element according to claim 18, characterized in that the second organic compound is an organic compound of a hole transporting property.

[Claim 23]

A light-emitting element according to claim 18, characterized in that the second organic compound is an organic compound having an aromatic amine skeleton.

[Claim 24]

A light-emitting element according to claim 18, characterized in that the material showing an electron accepter property is metal oxide.

[Claim 25]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing an organic compound and a metal, and a third layer made from metal oxide between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 26]

A light-emitting element characterized by having a first layer containing a light-emitting material, a second layer containing a organic compound and a metal, and a third layer containing a second organic compound different from the organic compound and metal oxide between an anode and a cathode, wherein the first layer, the second layer, and the third layer are sequentially stacked in a direction from the anode to the cathode, and the third layer is formed so as to be in contact with the cathode.

[Claim 27]

A light-emitting element according to claim 25 or claim 26, characterized in that the organic compound is an organic compound of an electron transporting property.

[Claim 28]

A light-emitting element according to claim 25 or claim 26, characterized in that the organic compound is a metal complex having a ligand containing π-conjugated skeleton.

[Claim 29]

A light-emitting element according to claim 25 or claim 26, characterized in that the second organic compound is an organic compound of a hole transporting property.

[Claim 30]

A light-emitting element according to claim 25 or claim 26, characterized in that the second organic compound is an organic compound having an aromatic amine skeleton.

[Claim 31]

A light-emitting element according to claim 25 or claim 26, characterized in that the metal is an alkali metal, an alkaline earth metal, or a rare earth metal.

[Claim 32]

A light-emitting element according to claim 25 or claim 26, characterized in that the metal oxide is a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide.

[Claim 33]

A light-emitting element according to any one of claim 1 to claim 32 which is characterized in that the cathode is made of a conductor formed by a sputtering method.

[Claim 34]

A light-emitting element according to claim 33, characterized in that the

conductor is a conductor which can transmit visible light.

[Name of Document] Specification

[Title of the Invention] LIGHT-EMITTING ELEMENT

[Technical Field]

[0001]

The present invention relates to a layered structure of a light-emitting element that has a light-emitting layer between an anode and a cathode and that can obtain light emission by applying an electric field.

[0002]

As examples of a photoelectronic device using an organic semiconductor material as a functional organic material, a light-emitting element (also referred to as an organic or inorganic organic hybrid electroluminescent element) and solar battery can be nominated, and these are devices utilizing an electrical property (carrier transporting property) and an optical property (light absorption or light-emitting) of the organic semiconductor material, and among these, a light-emitting element is showing a remarkable development.

[0003]

A light-emitting element comprises a layer containing a light-emitting material sandwiched between a pair of electrodes (anode and cathode) and its light-emitting mechanism is said to be that, by being recombined at the layer containing a light-emitting material, a hole injected from an anode and an electron injected from a cathode when voltage is applied between the electrodes are recombined at an emission center within the layer containing a light-emitting material to form molecular excitons,

and the molecular excitons release energy to emit light when returning to the ground state. Note that a singlet exciton and a triplet excition are known as an excited state, and it is considered that light emission is possible through either excited state.

[0004]

Lately, the reduction of driving voltage is successful (for example, see Patent Reference 1), and a metal of low work function (metal showing an electron donor property) such as an alkali metal, an alkaline earth metal, or a rare earth metal is doped into an organic compound to make an electron injecting layer, thereby lowering an energy barrier in injecting electrons from a cathode to an organic compound. In addition, according to this technique, driving voltage can be reduced even if a stabilized metal such as Al is used for the cathode.

[Patent Reference 1] Unexamined Patent Publication No. 10-270171

[0005]

Further, by applying this technique, the control of a light-emission spectrum of a light-emitting element is also successful (for example, see Patent Reference 2). Also in Patent Reference 2, although a metal showing an electron donor property is doped into an organic compound as an electron injecting layer, by increasing the thickness of this layer, an optical distance of a cathode and a light-emitting layer is changed, and the control of the light-emission spectrum emitted to outside is realized due to the interference effect of light.

[Patent Reference 2] Unexamined Patent Publication No. 2001-102175

[0006]

According to Patent Reference 2, by adopting the above-described electron injecting layer, even if the thickness of the electron injecting layer is increased in order

to control a light-emission spectrum, the increase of driving voltage is said to be small. However, in fact, unless a particular organic compound serving as a ligand such as bathocuproin (BCP) is used, driving voltage is greatly increased.

[0007]

That is, although the technique of an electron injecting layer shown in Patent References 1 and 2 controls a light-emission spectrum to improve color purity or improves a manufacturing yield by increasing the film thickness, there was a problem that, unless an organic compound serving as a ligand is selected, driving voltage rises and power consumption becomes large.

[0008]

Here, a principle of operation of a light-emitting element shown in Patent Reference 1 and Patent Reference 2 is explained using Fig. 2.

[0009]

Fig. 2 is a basic element structure of the conventional light-emitting element using an electron injecting layer mentioned in the aforementioned Patent References 1 and 2.

[0010]

In the conventional light-emitting element (Fig. 2), when forward bias is applied, holes injected from an anode 201 and electrons injected from a cathode 204 are recombined in a layer containing a light-emitting material 202, which leads to light emission. In this instance, an electron injecting layer 203 is a configuration in which a metal having a high electron donor property (alkali metal or alkaline earth metal) is doped into an organic compound.

[0011]

This electron injecting layer 203 has a function to flow electrons to inject electrons into the layer containing a light-emitting material 202. However, since electron mobility of an organic compound is less than hole mobility by about two orders of magnitude, if the film thickness is set to be comparable to a wavelength of visible light (on the order of submicron) for the purpose of, for example, controlling a light-emission spectrum, driving voltage is increased.

[Disclosure of Invention]

[Problems to be Solved by the Invention]

[0012]

In view of the foregoing problems, in the present invention, it is an object to provide a light-emitting element of which film thickness is easily increased and which can operate at low driving voltage by a novel means different from a light-emitting element using a material serving as a ligand as in a conventional technology. And thereby, it is an object to provide a light-emitting element with low power consumption and high color purity. At the same time, it is an object to provide a light-emitting element with low power consumption and high manufacturing yields.

[Means for Solving the Problems]

[0013]

The inventors, as a result of their earnest consideration, found that the problems can be solved by providing a light-emitting element having the following configurations.

[0014]

The present invention is a light-emitting element which has a first layer containing a light-emitting material, a second layer containing an n-type semiconductor, and a third layer containing a p-type semiconductor between an anode and a cathode,

and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided to be in contact with the cathode.

[0015]

Here, the n-type semiconductor is preferably metal oxide, especially, a compound or two or more compounds selected from a group consisting of zinc oxide, tin oxide, and titanium oxide are preferable. In addition, p-type semiconductor is preferably metal oxide, especially, a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide are preferable.

[0016]

The present invention is a light-emitting element which has a first layer containing a light-emitting material, a second layer containing an organic compound and a material showing an electron donor property, and a third layer containing a p-type semiconductor between an anode and a cathode, and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided so as to be in contact with the cathode.

[0017]

Here, the p-type semiconductor is preferably metal oxide, especially, a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide are preferable. In addition, the organic compound is preferably an organic compound showing an electron transporting property, especially, a metal complex having a ligand containing π-conjugated skeleton is preferable. In addition, the material showing an electron

donor property is preferably an alkali metal, an alkaline earth metal, or a rare earth metal.

[0018]

The present invention is a light-emitting element which has a first layer containing an light-emitting element, a second layer containing an n-type semiconductor, and a third layer containing an organic compound and a material showing an electron acceptor property between an anode and a cathode, and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided so as to be in contact with the cathode.

[0019]

Here, the n-type semiconductor is preferably metal oxide, especially, a compound or two or more compounds selected from a group consisting of zinc oxide, tin oxide, and titanium oxide are preferable. In addition, the organic compound is preferably an organic compound of a hole transporting property, especially, an organic compound having an aromatic amine skeleton is preferable. In addition, the material showing an electron acceptor property is preferably metal oxide.

[0020]

The present invention is a light-emitting element which has a first layer containing a light-emitting element, a second layer containing a first organic compound and a material showing an electron donor property, and a third layer containing a second organic compound and a material showing an electron acceptor property between an anode and a cathode, and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided so as to be in contact with the cathode.

[0021]

Here, the first organic compound is preferably an organic compound showing an electron transporting property, especially, a metal complex having a ligand containing π-conjugated skeleton is preferable. In addition, the material showing an electron donor property is preferably an alkali metal, an alkali earth metal, or a rare earth metal. In addition, the second organic compound is preferably an organic compound of a hole transporting property, especially, an organic compound having an aromatic amine skeleton is preferable. In addition, the material showing an electron acceptor property is preferably metal oxide.

[0022]

The present invention is a light-emitting element which has a first layer containing a light-emitting element, a second layer containing an organic compound and metal, and a third layer made from metal oxide between an anode and a cathode, and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided so as to be in contact with the cathode. Or, it is a light-emitting element which has a first layer containing a light-emitting element, a second layer containing an organic compound and metal, and a third layer containing an organic compound different from the organic compound contained in the second layer and metal oxide between an anode and a cathode, and in which the first layer, the second layer, and the third layer are sequentially provided in a direction from the anode to the cathode, and the third layer is provided so as to be in contact with the cathode.

[0023]

Here, the organic compound contained in the second layer is preferably an organic

compound of electron transporting property, especially, a metal complex having a ligand containing π-conjugated skeleton is preferable. In addition, the second organic compound contained in the third layer is preferably an organic compound of a hole transporting property, especially, an organic compound having an aromatic amine skeleton is preferable. In addition, the metal is preferably an alkali metal, an alkali earth metal, or a rare earth metal. In addition, the metal oxide is preferably a compound or two or more compounds selected from a group consisting of vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, and nickel oxide.

[0024]

Note that, in the light-emitting element of the present invention, even if a sputtering method is used to form a cathode, damage to the light-emitting element due to the sputtering is little and a light-emitting element showing good characteristics can be obtained. Therefore, a cathode can be formed using a conductor which can transmit visible light such as indium tin oxide (ITO: indium Tin Oxide) that is mainly formed by a sputtering method. In a case in which a transparent electrode made from such a conductor which can transmit visible light is used, a light-emitting element that can extract light emission also from a cathode side can be obtained.

[Effect of the Invention]

[0025]

According to the present invention, by a novel means different from a light-emitting element using a material serving as a ligand as in the conventional technology, the film thickness is easily increased and a light-emitting element which can be operated at low driving voltage can be obtained. And thereby, a light-emitting element with low power consumption and high color purity can be obtained. At the same time, a light-emitting

element with low power consumption and high manufacturing yield can be obtained.

[0026]

Further, by manufacturing a light-emitting device using the foregoing light-emitting element, a light-emitting device with high color purity, good manufacturing yield, and low power consumption can be provided.

[Best Mode for Carrying Out the Invention]

[0027]

Hereinafter, the embodiment modes of the present invention are described in detail with reference to a principle of operation and a specific structural example.

[0028]

First, a principle of operation of a light-emitting element of the present invention is explained using Fig. 1. Fig. 1 is a basic element structure of a light-emitting element of the present invention.

[0029]

A light-emitting element of the present invention (Fig. 1) has a configuration in which a first layer 102, a second layer 103, and a third layer 104 are sequentially provided between an anode 101 and a cathode 105 in a direction from the anode 101 to the cathode 105.

[0030]

The second layer 103 is a layer which produces electrons and transports the electrons, and is made from n-type semiconductor or a mixture containing that, or a mixture of an organic compound having a carrier transporting property and a material with high electron donor property. Also, the third layer 104 is a layer which produces holes and transports the holes, and is made from p-type semiconductor or a mixture

containing that, or a mixture of an organic compound having a carrier transporting property and a material with high electron acceptor property. Further, the first layer 102 is a layer containing a light-emitting material and is formed of a single layer or a plurality of layers.

[0031]

Note that, as for the first layer 102, the second layer 103, and the third layer 104, film thickness of each layer and a material forming each layer are selected to be stacked so that an emitting region is formed in the first layer 102.

[0032]

When forward bias is applied to the light-emitting element having such configuration, as shown in Fig. 1, electrons and holes each are flown out in an opposite direction from the vicinity of an interface between the second layer 103 and the third layer 104. Among thus produced carriers, electrons are recombined with holes injected from the anode 101, resulting in light emission in the first layer 102. On the other hand, holes pass through to the cathode 105. Note that, if focusing attention on the second layer 103 and the third layer 104 at this time, although it is a state in which reverse bias is applied to a p-n junction and an amount of generated carriers is not remarkably large, the amount is sufficient for operation of the light-emitting element.

[0033]

In the light-emitting element of the present invention as above, an optical distance can be adjusted by producing holes and increasing the film thickness of the third layer which can transport the holes. In this regard, it is different from the conventional light-emitting element that adjusts an optical distance by increasing the film thickness of an electron injecting layer 203 containing BCP, that is, a layer that

produces electrons and transports the electrons (Fig. 2).

[0034]

Generally, a hole mobility of an organic compound used as a hole transporting material has a higher mobility than electron mobility of an organic compound used as an electron transporting material. Therefore, as in the present invention, when an optical distance is adjusted by increasing the thickness of a layer that can move holes (third layer the increase of driving voltage associated with the increase of the film thickness can be better prevented.

[0035]

Hereinafter, one embodiment of the present invention is explained with reference to figures. However, the present invention can be carried out in many different embodiments, and those skilled in the art will easily understand that the modes and details can be modified in various ways without going beyond the substance and the scope of the present invention. Therefore, it should not be construed as being limited to the description of the embodiment modes.

[0036]

(Embodiment Mode 1)

In Embodiment Mode 1, a light-emitting element of the present invention is explained using Fig. 3.

[0037]

In Fig. 3, a light-emitting element has a structure in which an anode 301 is formed over a substrate 300, a first layer containing an light-emitting material 302 is formed over the anode 301, a second layer 303 is formed over the first layer 302, a third layer 304 is formed over the second layer 303, and an cathode 305 is formed thereover.

[0038]

Note that, as a material used for the substrate 300 here, it may be the one used in the conventional light-emitting element; for example, the one made of glass, quartz, transparent plastic, a substrate having flexibility, or the like can be used.

[0039]

As an anode material which can be used for the anode 301, the use of metal having a large work function (work function 4.0 eV or larger) such as alloys, electrically conductive compounds, or mixture of these is preferable. Note that, as specific examples of the anode materials, besides ITO (indium tin oxide), ITO containing silicon, IZO (indium zinc oxide) in which indium oxide is mixed with zinc oxide (ZnO) at 2 ~ 20 [%], aurum (Au), platinum (Pt), nickel (Ni), tungsten (W), chrome (Cr), molybdenum (Mo), ferrum (Fe), cobalt (Co), copper (Cu), palladium (Pd), nitride of metal material (TiN), or the like can be used.

[0040]

On the other hand, as a cathode material which is used for forming the cathode 305, the use of metal having a small work function (work function 3.8eV or smaller), such as alloys, electrically conductive compounds, or mixture of these is preferable. Note that, as specific examples of the cathode material, although it can be formed using a transition material containing a rare earth metal, besides an element belonging to group 1 and group 2 in the periodic table, that is, an alkaline metal such as Li, Cs, or the like, an alkaline earth metal such as Mg, Ca, Sr, or the like, alloys containing these (Mg:Ag, Al:Li), or compounds (LiF, CsF, CaF_2), it can also be formed of a laminated layer with a metal (including alloys) such as Al, Ag, ITO, or the like.

[0041]

Note that, the anode material and the cathode material mentioned above form the anode 301 and the cathode 305, respectively, by forming thin films by a vapor deposition method, a sputtering method, or the like. The film thickness is preferably 10 ~ 500 nm. A protective layer (barrier layer) comprising an inorganic material such as SiN or an organic material such as Teflon (registered trade mark) or styrene polymer may be lastly formed. The barrier layer may be either transparent or opaque, and the above inorganic material or organic material are formed by a vapor deposition method, a sputtering method, or the like.

[0042]

Further, in order to prevent the organic layer or the electrode of the light-emitting element from oxidation or moisture, desiccant such as SrO_x or SiO_x may be formed by an electron beam irradiation method, a vapor deposition method, a sputtering method, a sol-gel method, or the like.

[0043]

In addition, in the light-emitting element of the present invention, it has a configuration in which light generated by recombination of carriers within the layer containing a light-emitting material, which is the first layer, as shown in Fig. 3, is emitted from either the anode 301 or the cathode 305, or both to outside (arrows in the figure indicate emission directions). That is, when light emits from the anode 301 (Fig. 3 (A)), the anode 301 is formed of a light-transmitting material; when light emits from the cathode 305 side (Fig. 3 (B)), the cathode 305 is formed of a light-transmitting material; and when light emits from both of the anode 301 and the cathode 305 sides (Fig. 3 (C)), the anode 301 and the cathode 305 are formed of light-transmitting materials.

[0044]

In addition, the first layer 302 is formed by stacking a plurality of layers, and in this Embodiment Mode 1, it is formed by stacking a fourth layer 311, a fifth layer 312, and a sixth layer 313. Note that, the fourth layer 311 is a layer containing a hole injecting material, and the fifth layer 312 is a layer containing a hole transporting material. The sixth layer 313 contains a light-emitting material, which is a layer where a light-emitting region is formed upon being applied with an electric field.

[0045]

In addition, a known material can be used for the layer containing a light-emitting element, which is the first layer, and either of a low molecular based material or a high molecular based material can also be used.

[0046]

As a hole injecting material forming the fourth layer 311, a phthalocyanine compound is effective. For example, phthalocyanine (abbreviated as H_2 – Pc), copper phthalocyanine (abbreviated as: Cu – Pc), and the like can be used.

[0047]

As a hole transporting material forming the fifth layer 312, an aromatic amine based (that is, the one having a benzene ring-nitrogen bond) compound is preferred. As materials which are widely used, for example, besides 4,4'-bis [N-(3-methylphenyl)-N-phenyl-amino]-biphenyl (abbreviation: TPD), 4,4'-bis[N-(1-naphthyl)-N-phenyl-amino]-biphenyl (abbreviation: α-NPD), which is a derivative thereof, or a star burst aromatic amine compound such as 4,4',4"-tris(N,N-diphenyl-amino)-triphenyl amine (abbreviation: TDATA)~~,~~ and 4,4',4"-tris[N-(3-methylphenyl)-N-phenyl-amino]-triphenyl amine (abbreviation: MTDATA) can be given. In addition, a conductive inorganic compound alone, such as

oxide molybdenum, or a composite material mixed with the above organic compound can be used.

[0048]

As a light-emitting material contained in the sixth layer 313, for example, besides an organic compound such as quinacridone, coumarin, rubrene, styryl based pigments, tetraphenyl-buta-diene, anthracene, perylene, coronene, 12-phthaloperinone derivative, or the like, a metal complex such as tris(8-quinolinolate)aluminum (hereinafter referred to as Alq_3))) or the like can be given.

[0049]

The second layer 303 may be either a configuration consisting of n-type semiconductor such as zinc oxide, tin oxide, titanium oxide, zinc sulfide, zinc selenide, zinc telluride, or the like or a configuration including those n-type semiconductors. Alternatively, it may be a configuration in which an organic compound is doped with a material showing an electron donor property. An electron transporting material is preferable as the organic compound in this instance, and 2-(4-biphenyl)-5-(4-tert-butylphenyl)-l,3,4-oxadiazole (abbreviation: PBD) and the above-mentioned OXD-7, TAZ, p-EtTAZ, BPhen, and BCP can be given, and besides, a metal complex having a quinoline skeleton or a benzoquinoline skeleton such as Alq_3 with which conventionally showed an increase of driving voltage, tris(5-methyl-8-quinolinolate)aluminum (abbreviation: $Almq_3$), bis(10-hydroxybenzo[h]-quinolinato)beryllium (abbreviation $BeBq_2$), or the like and bis(2-methyl-8-quinolinolate)-4-phenylphenolato-aluminum (abbreviation: BAlq) can be given. On the other hand, as a material showing an electron donor property, an alkali metal such as Li or Cs, an alkali earth metal such as Mg, Ca, or Sr, or a rare earth

metal such as Er or Yb can be given. Besides, for example, an organic compound such as tetrathiafulvalene or tetramethylthisfulvalene which shows an electron donor property for Alq_3 can be used.

[0050]

The third layer 304 may be either a configuration consisting of p-type semiconductor such as vanadium oxide, chromium oxide, molybdenum oxide, cobalt oxide, nickel oxide, or the like or a configuration including those p-type semiconductors. Alternatively, it may be a configuration in which an organic compound is doped with a material showing an electron acceptor property. A hole transporting material is preferable as the organic compound in this instance, and an aromatic amine based compound is preferred. For example, besides TPD, α-NPD, which is a derivative thereof, or a star burst aromatic amine compound such as TDATA, MTDATA, and the like can be given. On the other hand, as a material showing an electron acceptor property, for example, metal oxide such as molybdenum oxide or vanadium oxide which shows an electron acceptor property with respect to α-NPD can be given. In addition, an organic compound such as tetracyanoquinodimethan (abbreviation: TCNQ) or 2, 3-dicyanonaphtoquinon (abbreviation: DCNNQ) which shows an electron acceptor property for α-NPD can be used.

[0051]

Through the above, a light-emitting element of the present invention can be formed. Note that, in this mode, although not illustrated, the structure may be such that a layer made from a material with good electron transporting property is provided to a part of the first layer 302 so as to be in contact with the second layer 303. Specific examples of a material with good electron transporting property are, for example, a layer made of

a metal complex having a quinoline skelton or a benzoquinoline skeleton, such as tris(8-quinolinolate)aluminum (abbreviation: Alq_3), tris(5-methyl-8-quinolinolate)aluminum (abbreviation: $Almq_3$), bis(10-hydroxybenzo[h]-quinolinato)beryllium (abbreviation: $BeBq_2$), or bis(2-methyl-8-quinolinolate)-4-phenylphenolato-aluminum (abbreviation: BAlq). In addition, a metal complex having an oxazole based or thiazole based ligand such as bis [2-(2-hydroxyphenyl)-benzooxazolate]zinc (abbreviation: $Zn(BOX)_2$), or bis [2-(2-hydroxyphenyl)-benzothiazolate]zinc (abbreviation: $Zn(BTZ)_2$) can be used. Further, besides the metal complex, 2-(4-biphenyl)-5-(4-tert-butylphenyl)-l,3,4-oxadiazole (abbreviation: PBD), l,3-bis[5-(p-tert-butylphenyl)-l,3,4-oxadiazole-2-yl]benzene (abbreviation: OXD-7), 3-(4-tert-butylphenyl)-4-phenyl-5-(4-biphenylyl)-l,2,4-triazole (abbreviation: TAZ), 3-(4-tert-butylphenyl)-4-(4-ethylphenyl)-5-(4-biphenylyl)-l,2,4-triazole (abbreviation: p-EtTAZ), bathophenanthroline (abbreviation: BPhen), bathocuproin (abbreviation BCP), or the like can be used.

[0052]

In the above-described light-emitting element of the present invention, when the cathode is formed of a conductive material that transmits visible light, as shown in Fig. 3(B), light emission can be extracted from the cathode side. In addition, when the anode is formed of a conductive material that transmits visible light, as shown in Fig. 3(A), light emission can be extracted from the anode side. Further, when both of the cathode and the anode are formed of a conductive material that transmits visible light, as shown in Fig. 3(C), light emission can be extracted from both sides.

[0053]

As a conductive material that can transmit visible light and has a relatively high conductivity, as described earlier, ITO, IZO, and the like can be given. Because these have a high work function, these are generally said to be unsuitable as a material forming a cathode.

[0054]

However, as for the light-emitting element of the present invention, since the configuration is provided with a layer which produces holes and transports the holes and a layer which produces electrons and transports the electrons, even if a material with a high work function such as ITO or IZO is used, driving voltage is not increased. Therefore, as for the light-emitting element of the present invention, as a material for forming the cathode, ITO, IZO, or the like can be used.

[0055]

Further, in the light-emitting element of the present invention, even if a sputtering method is used for forming the cathode, damage to the light-emitting element due to sputtering is little and a light-emitting element showing good characteristics can be obtained. This is an advantage in forming a cathode using a conductive material that transmits visible light such as ITO, which is mainly formed by a sputtering method.

[0056]

(Embodiment Mode 2)

In Embodiment Mode 2 of the present invention, a configuration of a light-emitting element of the present invention is explained using Fig. 4.

[0057]

Note that, as for a substrate 400, an anode 401, a first layer 402, a second layer 403, a third layer 404, and a cathode 405, because they can be formed using the same materials

and in the same manners as Embodiment Mode 1, explanation is omitted.

[0058]

In addition, Fig. 4 has a structure in which the cathode 405 is formed over the substrate 400, the third layer 404 is formed over the cathode 405, the second layer 403 is formed over the third layer 404, the first layer containing a light-emitting element 402 is formed over the second layer 403, and the anode 401 is formed thereover.

[0059]

In addition, in a light-emitting element of the present invention, it has a configuration in which light generated by recombination of carriers within the layer containing a light-emitting material, which is the first layer, is emitted from either the anode 401 or the cathode 405, or both to outside. That is, when light emits from the anode 401 (Fig. 4 (A)), the anode 401 is formed of a light-transmitting material; when light emits from the cathode 405 side (Fig. 4 (B)); the cathode 405 is formed of a light-transmitting material; and when light emits from both of the anode 401 and the cathode 405 sides (Fig. 4 (C)), the anode 401 and the cathode 405 are formed of light-transmitting materials.

[0060]

Through the above, the light-emitting element of the present invention can be manufactured.

[0061]

In the above-described light-emitting element of the present invention, when the cathode is formed of a conductive material that transmits visible light, as shown in Fig. 4(A), light emission can be extracted from the cathode side. In addition, when the anode is formed of a conductive material that transmits visible light, as shown in Fig.

4(B), light emission can be extracted from the anode side. Further, when both of the cathode and the anode are formed of a conductive material that transmits visible light, as shown in Fig. 4(C), light emission can be extracted from both sides.

[0062]

Note that, as mentioned in Embodiment Mode 2, as a conductive material that can transmit visible light and has a relatively high conductivity, as described earlier, ITO, IZO, and the like can be given. Because these have a high work function, these are generally said to be unsuitable as a material for forming a cathode.

[0063]

However, as for the light-emitting element of the present invention, since the configuration is provided with a layer which produces holes and transports the holes and a layer which produces electrons and transports the electrons, even if a material with a high work function such as ITO or IZO is used, driving voltage is not increased. Therefore, as for the light-emitting element of the present invention, as a material for forming the cathode, ITO, IZO, or the like can be used.

[0064]

(Embodiment Mode 3)

In this embodiment, a light-emitting element is manufactured over a substrate 500 made of glass, quartz, metal, bulk semiconductor, transparent plastic, flexible substrate, or the like. A passive light-emitting device can be manufactured by manufacturing a plurality of such light-emitting elements over one substrate. In addition, besides the substrate made of glass, quartz, transparent plastic, flexible substrate, or the like, as shown in Fig. 5 for example, a light-emitting element which is in contact with a thin film transistor (TFT) array may be manufactured. Here, 511 and 512 denote a TFT,

and 513 is a light-emitting element of the present invention is manufactured. Within the light-emitting element 513, an anode 514, a first layer, a second layer, and a third layer as 515, and a cathode 516 can be manufactured. Further, a wiring 517 is formed in contact with the cathode 516,and thus, an active matrix light-emitting device which controls driving of a light-emitting element by a TFT can be manufactured. Note that, the structure of the TFT is not especially limited. For example, either a staggered type or a reverse staggered type may be used. In addition, the crystallinity of a semiconductor layer composing the TFT also is not especially limited, and either crystalline one or amorphous one may be used.

[Embodiment 1]

[0065]

In this embodiment, a light-emitting element structure of the present invention is explained using Fig. 6.

[0066]

First, an anode 601 of the light-emitting element is formed over a substrate 600. ITO, which is a transparent conductive film, was used as a material, and formed in a thickness of 110 nm by a sputtering method. A shape of the anode 601 is 2 mm square.

[0067]

Next, a first layer containing a light-emitting material 602 is formed over the anode 601. Note that, the first layer containing a light-emitting material 602 of this embodiment has a layered structure composed of three layers 611, 612, and 613.

[0068]

A substrate on which the anode 601 was formed was secured to a substrate holder of a

vacuum deposition device in such a way that the surface on which the anode 601 was formed was down; copper phthalocyanine (hereinafter, shown as Cu-Pc) was put into an evaporation source installed in the internal of the vacuum deposition device; and 611 made from a hole injecting material to have a thickness of 20 nm by a vapor deposition method using a resistive heating method was formed. Note that, as a material for forming 611, a known hole injecting material can be used.

[0069]

Next, 612 is formed of a material with a good hole transporting property. As a material for forming 612, a known hole transporting material can be used, and in this embodiment, α-NPD was formed to have a thickness of 40 nm by the same process.

[0070]

Next, 613 is formed. As a material for forming 613, a known light-emitting material can be used, and in this embodiment, Alq_3 was formed to have a thickness of 40 nm by the same process.

[0071]

Thus, three layers 611, 612, and 613 are formed as stacked layers. Next, a second layer 103 is formed. In this embodiment, , Alq_3 was used as an electron transporting material (host material) and Mg was used as a material showing an electron donor property (guest material) for Alq_3, and the second layer 103 was formed to have a thickness of 30nm by a co-evaporation method. Proportion of the guest material was set to be 1 wt %.

[0072]

Next, a third layer 604 is formed. In this embodiment, α-NPD was used as a hole transporting material (host material) and molybdenum oxide was used as a material

showing an electron acceptor property (guest material) for the α-NPD, and the third layer was formed to have a thickness of 150 nm by a co-evaporation method. Proportion of the guest material was set to be 25 %.

[0073]

Next, a cathode 605 is formed by a sputtering method or a vapor deposition method. Note that, in this embodiment, the cathode 605 is obtained by forming aluminum (150 nm) by a vapor deposition method over the third layer 604.

[0074]

In the above manner, the light-emitting element of the present invention was formed. Luminance-voltage characteristics of the obtained light-emitting element is shown in Fig. 11, current-voltage characteristics of the obtained light-emitting element is shown in Fig. 12, and an emission spectrum of the obtained light-emitting element when current of 1 mA was applied is shown in Fig. 13, each.

[0075]

When a voltage was applied to the light-emitting element that was formed, the light-emission start voltage (here, a voltage when a luminance is 1 cd/m^2) was 6.0 V. In addition, the luminance when a current of 1 mA was applied was 1130 cd/m^2. In addition, the CIE chromaticity coordinates at this time was (X, Y) = (0.29, 0.63), which was green with good color purity.

[0076]

(Comparative Example 1)

In this Comparative Example 1, the conventional light-emitting element in which the second layer and the third layer of the present invention are not used but an electron injecting layer 703 is provided instead is explained using Fig. 7. As the electron

injecting layer 703, as is the case with the second layer 603 of Embodiment 1, a configuration in which Mg, which is a material showing an electron donor property, is doped into an electron transporting material Alq_3 is adopted. A thickness of the electron injecting layer 703 was, as is the case with the second layer of Embodiment 1, set to be 30 nm. Also, the other anode 701, layer containing a light-emitting material 702, and cathode 704 have exactly the same configurations as Embodiment 1. Therefore, Embodiment 1 is thicker by the thickness of the third layer 604 (150 nm) compared to this Comparative Example 1.

[0077]

Luminance-voltage characteristics of the obtained light-emitting element is shown in Fig. 11, current-voltage characteristics of the obtained light-emitting element is shown in Fig. 12, and an emission spectrum of the obtained light-emitting element when current of 1 mA was applied is shown in Fig. 13, each. When a voltage was applied to the light-emitting element that was formed, the light-emission start voltage was 5.4 V. In addition, the luminance when a current of 1 mA was applied was 1360 cd/m^2. In addition, the CIE chromaticity coordinates at this time was (X, Y) = (0.34, 0.58), which was yellow green with not so good color purity.

[0078]

From the above results, it was revealed that, although Embodiment 1 of the present invention has a total thickness which is thicker by 150 nm compared to this Comparative Example 1, the driving voltage (6.0 V) was almost the same as this Comparative Example 1 (5.4 V). In addition, when comparing the emission spectrum in Fig. 13, the spectrum width of Embodiment 1 is narrower compared to the emission spectrum of Comparative Example 1, and it can be considered that this leads to the

improvement of color purity.

[0079]

(Comparative Example 2)

In this Comparative Example 2, the conventional light-emitting element in which all of an anode 801, a layer containing a light-emitting material 802, and a cathode 804 have the same configuration as Embodiment 1 and an electron injecting layer 803 is provided is explained using Fig. 8. Here, the configuration of the electron injecting layer 803 is the same as Comparative Example 1, but the total film thickness was adjusted to be the same as Embodiment 1 by making the film thickness be 180 nm.

[0080]

Luminance-voltage characteristics of the obtained light-emitting element is shown in Fig. 11, current-voltage characteristics of the obtained light-emitting element is shown in Fig. 12, and an emission spectrum of the obtained light-emitting element, when current of 1 mA was applied is shown in Fig. 13, each. When a voltage was applied to the light-emitting element that was formed, the light-emission start voltage was 14.0 V. In addition, the luminance when a current of 1 mA was applied was 1050 cd/m^2. In addition, the CIE chromaticity coordinates at this time was (X, Y) = (0.25, 0.63), which was green with good color purity.

[0081]

From the above results, it is revealed that, although the spectrum width is narrow, which can be seen from Fig. 13, and color purity is good in the configuration of Comparative Example 2, the driving voltage drastically increased compared to Embodiment 1 of the present invention in which the film thickness is the same.

[0082]

Therefore, it was revealed that, the practice of the present invention can improve color purity by increasing the film thickness and can prevent the increase of the driving voltage at the same time even if the film thickness is increased.

[Embodiment 2]

[0083]

In this example, a light-emitting device having a light-emitting element of the present invention in a pixel portion is explained using Fig. 9. Note that, Fig. 9(A) is a top view showing a light-emitting device and Fig. 9(B) is a cross-sectional view of Fig. 9(A) taken along A-A'. 901 indicated by dotted line is a driver circuit portion (a source side driver circuit), 902 is a pixel portion, and 903 is a driver circuit portion (a gate side driver circuit). In addition, 904 is a sealing substrate, 905 is a sealing agent, and an inside 907, which is surrounded by the sealing agent 905, is a space.

[0084]

Note that, 908 is a wiring for transmitting signals to be inputted to the source side driver circuit 901 and the gate side driver circuit 903, and receives video signals, clock signals, start signals, reset signals, or the like from an FPC (flexible printed circuit) 909 serving as an external input terminal. Note that, although only the FPC is illustrated here, a printed wiring board (PWB) may be attached to this FPC. A light-emitting device according to this specification includes not only a main body of a light-emitting device itself, but also a state in which the FPC or the PWB are attached thereto.

[0085]

Then, a cross-sectional structure will be explained using Fig. 9(B). A driver circuit portion and a pixel portion are formed over a substrate 910, and here, the source side driver circuit 901, which is the driving circuit portion, and the pixel portion 902 are

shown.

[0086]

Note that, in the source side driver circuit 901, a CMOS circuit in which an n-channel TFT 923 and a p-channel TFT 924 are combined . Also, a TFT which forms a driver circuit may be formed of a known CMOS circuit, PMOS circuit, or NMOS circuit. In addition, in this Embodiment, although a driver integrated type in which a driver circuit is formed over a substrate is described, it does not always have to be as such and can be formed outside instead of over a substrate.

[0087]

In addition, the pixel portion 902 is formed of a plurality of pixels including a switching TFT 911, a current control TFT 912, and an anode 913 electrically connected to the drain of the current control TFT 912. Note that, an insulator 914 is formed to cover the edge portion of the anode 913. Here, it is formed by using a positive type photosensitive acrylic resin film.

[0088]

In addition, in order to improve film-formation property, an upper edge portion or a lower edge portion of the insulator 914 is formed to have curved faces having curvature. For example, in case that positive type photosensitive acrylic is used as a material for the insulator 914, it is preferable to provide curved faces having radius of curvatures (0.2 μm ~ 3 μm) only at the upper edge portion of the insulator 914. In addition, as the insulator 914, either a negative type that becomes insoluble to etchant by photosensitive light or a positive type that becomes dissoluble to etchant by light can be used, and not only organic compounds but also both of organic compounds and inorganic compounds, for example, silicon oxide, silicon oxynitride, siloxane, or the like can be used.

[0089]

Over the anode 913, the first to third layers 916 and a cathode 917 are respectively formed. Here, as a material used for the anode 913, it is preferable to use a material having a large work function. For example, besides a single layer film such as an ITO (indium tin oxide) film, ITSO (indium tin silicon oxide), an indium zinc oxide (IZO) film, a titanium nitride film, a chromium film, a tungsten film, a Zn film, a Pt film, or the like, a laminated layer with a film containing titanium nitride and aluminum as a main component, a three laminated layer with a film containing titanium nitride and aluminum as main component and a titanium nitride film, or the like can be used. Note that, if a layered structure is employed, a resistance as a wiring is low and good ohmic contact is obtained, and further it can function as an anode.

[0090]

In addition, the first to third layers 916 are formed by a vapor deposition method using an evaporation mask or by an ink-jet method. The first to third layers 916 comprise a first layer containing a light-emitting material, a second layer containing an n-type semiconductor, and a third layer containing a p-type semiconductor, and the first, second, and third layers are sequentially stacked in a direction from the anode to cathode, and the third layer is formed so as to be in contact with the cathode. In addition, as a material used for a layer containing a light-emitting material, an organic compound in a single layer, a laminated layer, or a mixed layer is generally used in many cases, but in the present invention, a configuration in which an inorganic compound is used for a part of a film made from an organic compound is included.

[0091]

Further, as a material used for the cathode 917 formed over the first to third layers 916,

a material having a small work function (Al, Ag, Li, Ca, or alloys of these such as MgAg, MgIn, AlLi, CaF_2, or CaN) can be used. Note that, in case that light generated in the first to third layers 916 is made pass through the cathode 917, as the cathode 917, it is good to use a laminated layer comprising a thin metal film whose film thickness is decreased and a transparent conductive film ITO (indium oxide tin oxide alloy), ITSO (indium tin silicon oxide), indium oxide zinc oxide alloy (In_2O_3 - ZnO), zinc oxide ((ZnO) or the like).

[0092]

Further, by bonding the sealing substrate 904 and the element substrate 910 with the sealing agent 905, the structure is such that a light-emitting element 918 is provided in the space 907 which is surrounded by the element substrate 901, the sealing substrate 904, and the sealing agent 905. Note that, the space 907 includes a configuration filled with the sealing agent 905 besides the case filled with inert gases (such as nitrogen or argon).

[0093]

Note that, it is preferable to use epoxy-based resin as the sealing agent 905. In addition, it is desirable that these materials are materials which do not penetrate moisture or oxygen as much as possible. In addition, as a material used for the sealing substrate 904, besides a glass substrate or a quartz substrate, a plastic substrate made from FRP (Fiberglass-Reinforced Plastics), PVF (polyvinyl fluoride), Myler, polyester, acrylic, or the like can be used.

[0094]

In the above manner, a light-emitting device having a light-emitting element of the present invention can be obtained.

[0095]

Note that, the light-emitting device shown in this Embodiment can be practiced by freely combining with the configuration of the light-emitting element shown in Embodiment 1. Further, the light-emitting device shown in this Embodiment may use a chromatic conversion film such as a color filter as needed.

[Embodiment 3]

[0096]

In this Embodiment, various electric appliances completed by using a light-emitting device having a light-emitting element in the present invention will be explained using Fig. 10.

[0097]

As electric appliances manufactured by using a light-emitting device formed by using the present invention, a television, a video camera, a digital camera, a goggles-type display (a head mount display), a navigation system, a sound reproduction device (a car audio equipment, a audio set, and the like), a notebook personal computer, a game machine, a portable information terminal (a mobile computer, a cellular phone, a portable game machine or an electronic book, and the like), an image reproduction device provided with a recording medium (specifically, a device which can reproduce a recording medium such as a digital video disc (DVD) and so forth and is provided with a display device which can display the image) can be given. Specific examples of these electric appliances are shown in Fig. 10.

[0098]

Fig. 10(A) is a display device, and includes a housing 1001, a support table 1002, a display portion 1003, a speaker portion 1004, a video input terminal 1005, and the like.

The display device is manufactured by using the light-emitting device formed by using the present invention for the display portion 1003. Note that, the display device includes all of the devices for displaying information, such as for a personal computer, for receiving TV broadcasting, for displaying an advertisement, and the like.

[0099]

Fig. 10(B) is a video camera, and includes a main body 1301, a display portion 1302, a housing 1303, an external connecting port 1304, a remote control receiving portion 1305, an image receiving portion 1306, a battery 1307, a sound input portion 1308, an operation key 1309, an eyepiece portion 1310, and the like. The video camera is manufactured by using the light-emitting device having the light-emitting element of the present invention for the display portion 1302.

[0100]

Fig. 10(C) is a cellular phone, and includes a main body 1501, a housing 1502, a display portion 1503, a sound input portion 1504, a sound output portion 1505, an operation key 1506, an external connecting port 1507, an antenna 1508, and the like. The cellular phone is manufactured by using the light-emitting device having the light-emitting element of the present invention for the display portion 1503.

[0101]

As set forth above, the application range of the light-emitting device having the light-emitting element of the present invention is extremely large, and the light-emitting element used for the light-emitting device is formed by using the light-emitting element of the present invention, and thus having a feature of low driving voltage and long lifetime. Therefore, by applying this light-emitting device to electric appliances in various fields, low electric power consumption and long lifetime can be realized.

[Brief Description of the Drawings]

[0102]

[Fig. 1] An explanatory view of the element structure of a light-emitting element of the present invention.

[Fig. 2] An explanatory view of the element structure of a light-emitting element of the present invention.

[Fig. 3] An explanatory view of the element structure of a light-emitting element of the present invention.

[Fig. 4] An explanatory view of the element structure of a light-emitting element of the present invention.

[Fig. 5] An explanatory view of a light-emitting device.

[Fig. 6] An explanatory view of the element structure of a light-emitting element of the present invention.

[Fig. 7] An explanatory view of the element structure of a comparative example with respect to a light-emitting element of the present invention.

[Fig. 8] An explanatory view of the element structure of a comparative example with respect to a light-emitting element of the present invention.

[Fig. 9] An explanatory view of a light-emitting device.

[Fig. 10] An explanatory view of electric appliances.

[Fig. 11] A view showing voltage-luminance characteristics of a light-emitting device.

[Fig. 12] A view showing current-voltage characteristics of a light-emitting

device.

[Fig. 13] A view showing emission spectrum of a light-emitting device.

[Name of Document] Drawings

[Fig. 1]

[Fig. 2]

[Fig. 3]

[Fig. 4]

[Fig. 5]

[Fig. 6]

[Fig. 7]

[Fig. 8]

[Fig. 9]

[Fig. 10]

[Fig. 11]

[Fig. 12]

[Fig. 13]

[Name of Document] Abstract

[Abstract]

[Problem]

Provide a light-emitting element of which film thickness is easily increased and which can operate at low driving voltage by a novel means different from a conventional technology. And thereby, provide a light-emitting element with low power consumption and high color purity. At the same time, provide a light-emitting element with low power consumption and high manufacturing yields.

[Solving Means]

A light-emitting element is manufactured having a configuration in which a first layer containing a light-emitting material 102, a second layer 103, and a third layer 104 are sequentially provided between an anode 101 and a cathode 105 in a direction from the anode 101 to the cathode 105, and the third layer 104 is in contact with the cathode 105. The second layer 103 is formed by using n-type semiconductor or a mixture containing that, or a mixture of an organic compound having a carrier transporting property and a material with high electron donor property. In addition, the third layer 104 is formed by using p-type semiconductor or a mixture containing that, or a mixture of an organic compound having a carrier transporting property and a material with high electron acceptor property.

[Selected Drawing] Fig. 1